

REMARKS/ARGUMENTS

Status of Application

Claims 1-12 and 14-60 are pending. Claims 1-46 were rejected over the prior art for anticipation or obviousness as follows:

- Claims 1-3, 5-6, 9-13, 5, 7, 23, 27-31, 37-39, 45-46 were rejected under 35 U.S.C. 102(b) as being anticipated by Wood et al. (U.S. 5675149) (“Wood”);
- Claim 16 was rejected under 35 U.S.C. 103(a) as being unpatentable over Wood in view of Wood (U.S. 5420419) (“Wood 2”);
- Claims 8, 16-18 were rejected under 35 U.S.C. 103(a) as being unpatentable over Wood in view of Knauth et al. (U.S. 6610984) (“Knauth”);
- Claims 24-26, 32-36, 40-43 were rejected under 35 U.S.C. 103(a) as being unpatentable over Wood in view of Walsall et al. (U.S. 4428382) (“Walsall”);
- Claims 1-3, 5, 13, 15, 20, 23, 27-31, 39 were rejected under 35 U.S.C. 103(a) as being unpatentable over Sheffer (U.S. 6072150) (“Sheffer”) in view of Eryurek et al. (U.S. 5746511) (“Eryurek”);
- Claims 1, 3-5, 11-12, 23-28, 39-43, 45-46 were rejected under 35 U.S.C. 103(a) as being unpatentable over Walsall in view of Needham (U.S. 4466748) (“Needham”);
- Claims 1-3, 5, 11-16, 19, 21, 23-25, 27-28, 39-41, 44-46 were rejected under 35 U.S.C. 103(a) as being unpatentable over Seifert et al. (U.S. 6652452) (“Seifert”) in view of Eryurek and Pavlidis et al. (U.S. 7111980) (“Pavlidis”);
- Claims 1-3, 5-7, 9-12, 20, 23, 27-28, 46 were rejected under 35 U.S.C. 103(a) as being unpatentable over Barnes (GB10147690) (“Barnes”) in view of Eryurek;
- Claims 1, 3-4, 21-22, 29, 31, 37-38 were rejected under 35 U.S.C. 103(a) as being unpatentable over Barnes and Eryurek, as applied to claims 1-3, 5-7, 9-12, 20, 23, 27-28, 46 above, and further in view of Maccarone (U.S. 6742925) (“Maccarone”); and

- Claim 4 was rejected under 35 U.S.C. 103(a) as being unpatentable over Wood in view of Ludlow (U.S. 5265958) (“Ludlow”).

Applicants have amended the claims in a manner that is believed to overcome the prior art rejections.

Applicants have also made a number of formal amendments, namely amending the claims to remove references to “the or each,” which references were appropriate before multiple dependent claims were amended to remove multiple dependencies, and amending dependent claims to eliminate a dependency to a now-cancelled claim.

Distinguishing Features

Applicants will, for the sake of general explanation, summarize some of the features of the present invention. It is believed that the amended claims recite various ones of these features, although it is not necessary for all embodiments of the invention to exhibit every feature discussed below. To the extent that there is any inconsistency between the claims and the remarks, the claim language should be given precedence.

Embodiments of the present invention achieves a number of advantages and benefits which are not envisaged in the prior art as a whole. The specific differences between the most relevant citations and the claimed invention will be discussed below.

An important feature of the present invention is that the reference heat source is placed in the scene which is to be mapped: that is, at any one instant, the target object(s) which the observer wishes to map and the reference heat source are “visible” to the thermal imaging device. This is quite different to conventional calibration systems in which a reference plate is presented to the thermal detector before mapping can begin, in order to set an approximate calibration level or to correct for pixel-to-pixel differences. In known techniques, the reference plate covers the whole field of view of the thermal detector – i.e., takes up the whole “scene.” This will be demonstrated with respect to the Examiner’s citations below.

It must be emphasised that the correction of pixel-to-pixel variations is not the subject of the present invention. Rather, the claimed apparatus and methods address the problem

of how to produce a high accuracy thermal image of a scene, with the indicated temperatures accurately reflecting those of the actual objects in the scene.

By placing a reference source within the scene under observation, the present invention makes it possible to perform calibration in substantially real time: each image frame can be corrected instantaneously, using correction data appropriate to that particular frame. Thus, the calibration is significantly more accurate since the correction takes into account the atmospheric conditions to which the scene is subjected at the instant at which the scene is mapped (as well as inherent variation in the detector's response). No pre-calibration routine is capable of such accuracy.

In the present invention, the calibration is performed by determining a correction based on the known temperature of the reference heat source and the detected radiation from those detectors in the FPA which receive radiation from that heat source, i.e., a subset that includes fewer than all of the detectors in the array. The correction thus determined is then used to adjust other pixels in the image. This is not contemplated in the prior art references, all of which perform only corrections of data from certain detectors based on reference radiation previously received by that same detector.

Prior Art Rejections

The Examiner has rejected all the claims, with various of the rejections using one of the following five primary references:

- Wood et al. (U.S. 5675149) (“Wood”);
- Sheffer (U.S. 6072150) (“Sheffer”);
- Walsall et al. (U.S. 4428382) (“Walsall”);
- Seifert et al. (U.S. 6652452) (“Seifert”); and
- Barnes (GB1014769) (“Barnes”).

Secondary references include the following

- Wood (U.S. 5420419) (“Wood 2”);
- Knauth et al. (U.S. 6610984) (“Knauth”);
- Walsall;

- Eryurek et al. (U.S. 5746511) (“Eryurek”);
- Needham (U.S. 4466748) (“Needham”);
- Pavlidis et al. (U.S. 7111980) (“Pavlidis”);
- Maccarone (U.S. 6742925) (“Maccarone”); and
- Ludlow (U.S. 5265958) (“Ludlow”).

Applicants will now address the prior art rejections in detail under subheadings corresponding to the primary references.

I) Wood et al (US 5675149)

The Examiner has rejected the independent claims (1, 27, and 29) and most of the dependent claims as anticipated by Wood, and most of the remaining dependent claims as obvious over Wood in view of one of Wood 2, Knauth, Walsall, and Ludlow.

However, all that Wood in fact discloses is a conventional pre-calibration technique for correcting pixel-to-pixel variations: that is, differences in the response of each thermal detector to incident radiation. This is made clear at column 4, lines 10 to 20: the correction is accomplished for each individual pixel by holding a reference plate before the lens while operating the camera, calculating the required sensor calibration constants and storing them for retrieval at any later time.

To achieve this, the reference plate must irradiate every pixel of the array – i.e., fill the camera’s field of view. Hence it is not possible to view the scene under observation at the same time as carrying out calibration. In particular, the “scene” being “mapped” by the camera when the reference plate is in position cannot also include at least one target object as required by claim 1.

Moreover, there is no suggestion that any subset of fewer than all the detectors ought to be used to determine a correction which is then applied to other pixels, whose detectors are receiving radiation at the same time. Further, since Wood is entirely concerned with correction of pixel-to-pixel variations, there is no motivation to consider such a departure since it would not be possible to correct pixel-to-pixel variations in this way.

Applicants respectfully submit that the independent claims are neither disclosed nor suggested by Wood. As will be discussed below, none of the other citations disclose anything which would assist one of ordinary skill in the art in arriving at the present invention.

Wood 2 is cited as showing an array of bolometers as a detector array. Applicants do not submit that using an array of bolometers is new, but respectfully submit that Wood 2 does not overcome the critical shortcomings of Wood (1).

Knauth is cited for its disclosure of a FPA sensor array (microbolometer array) that is kept to an ambient temperature including a room temperature by Peltier-junction heat engine. Applicants do not submit that stabilizing the temperature of an array using a Peltier-effect device is new, but respectfully submit that Knauth does not overcome the critical shortcomings of Wood.

Walsall is discussed below in connection with its use as a primary reference, but is cited as a secondary reference for its disclosure of measuring temperatures of a human subject. For the reasons discussed below, Walsall does not overcome the critical shortcomings of Wood.

Ludlow is cited as showing contact sensors used to measure the temperature of the heat source. Applicants do not submit that using contact sensors is new, but respectfully submit that Ludlow does not overcome the critical shortcomings of Wood.

Therefore, Applicants respectfully submit that the independent claims are neither disclosed nor suggested by Wood, alone or in combination with any or all of Wood 2, Knauth, Walsall, and Ludlow.

The dependent claims depend directly or indirectly from claims 1, 27, or 29, all of which are believed allowable, and set forth additional limitations. For this reason alone the dependent claims are allowable.

2) Sheffer (US 6072150)

The Examiner has rejected the independent claims (1, 27, and 29) and most of the dependent claims as obvious over Sheffer in view of Eryurek, stating that Sheffer discloses all of

the features of claim 1 except the manner in which the calibration is determined, and that this is rendered obvious by Eryurek.

In Sheffer, a laser is aimed at a solder joint on a circuit board and, after inputting a pulse of laser energy, the infra-red “time signature” of the joint is observed using a single-element IR detector (e.g., sensor 28). In some embodiments, several such sensors are provided to monitor the response of multiple joints on the circuit board.

Sheffer describes the use of multiple reference sources 84 and 86, as shown in Figure 4b, which are located beneath the conveyor belt on which the circuit board is supported during soldering and testing. During calibration, the reference sources are sequentially measured by each of the single-element detectors.

Sheffer’s system is fundamentally different from that of the present invention. The reference sources are located in a position where they cannot be “seen” during the measurements on the circuit board. The calibration, by design, occurs before the measurement. There is no notion of a subset of sensors receiving radiation from a reference source while other detectors in the FPA receive radiation from other portions of the scene at the same time. Each IR detector only views the reference source(s) between testing circuit boards. It is not possible to include both the target object and the reference source in the same scene and hence no real-time calibration is available.

Further, even if it were argued that Sheffer’s multiple individual detectors constituted an FPA, each detector is calibrated with the reference sources, so there is no suggestion of determining a correction based on a subset of detectors since all the detectors receive the calibration radiation (and not while the actual measurements of the scene are being made).

Eyurek does not suggest any way that Sheffer’s teachings could be modified to provide the claimed invention. Eyurek does not show an IR detector, but rather a temperature sensor whose resistance varies with temperature. Eyurek could arguably be considered to generate real-time calibration information in the sense that it provides a temperature-dependent signal (Johnson noise) while its resistance is being monitored. However, while generating and

storing calibration information is shown, there is no suggestion of having calibration information generated in real-time using a subset of an array of detectors.

Therefore, Eryurek discloses none of the above mentioned claimed features that are missing from Sheffer, and so would not assist one of ordinary skill in the art in arriving at the present invention. Therefore, Applicants respectfully submit that the independent claims are neither disclosed nor suggested by Sheffer in combination with Eryurek.

The dependent claims depend directly or indirectly from claims 1, 27, or 29, all of which are believed allowable, and set forth additional limitations. For this reason alone the dependent claims are allowable.

3) Walsall et al (US 4428382)

The Examiner has rejected the independent claims (1, 27, and 29) and most of the dependent claims as obvious over Walsall in view of Needham, stating that Walsall discloses all of the features of the rejected claims except explicitly teaching a microprocessor and the particular calibration process, as claimed by applicant.

The Examiner asserts that Walsall discloses making a thermal map of the human body which is calibrated against a known reference temperature. However, the system disclosed by Walsall is distinct from the invention in numerous ways.

First, Walsall does not disclose a thermal imaging device as required by each independent claim, and certainly not a focal plane array (FPA) detector. Rather, Walsall's technique uses an IR thermometer for measuring the temperature of a single point on the target body, which does not constitute an "image."

Further, the use of the forehead temperature as a reference does not correspond to the use of a reference heat source as claimed, since Walsall takes the temperature of the forehead using the same IR thermometer. As such, its temperature cannot be said to be "known" since its measurement is subject to all the same errors as will be manifest in the measurements taken from other parts of the body. Therefore, this "reference temperature" cannot be used to calibrate the device; all that is achieved is a relative temperature measurement which is not accurate in any

“absolute” sense and could not, for example, be compared in any meaningful manner with any external data.

Significantly, as a result of the use of an IR thermometer as opposed to an imaging device, in Walsall, the “scene” being viewed amounts to a single point on the body, and it is not possible to include the “reference point” (i.e., the forehead) in the same scene as the parts of the body that are to be diagnosed (the “target object(s)”). Hence, Walsall does not disclose the scene containing a target object in addition to a reference heat source. Thus, there is no possibility of real-time calibration. It is also impossible to deduce a correction from a subset of detectors that includes fewer than all of the detectors in the FPA of detectors , since there is only one detector present.

There is nothing in Walsall which would prompt one of ordinary skill in the art to make the substantial changes which would be necessary to arrive at the present invention.

Needham is cited as showing “a device comprising a protective cover covered with black 43 to form a blackbody heat radiation source / reference. The device also comprising a microprocessor for comparison a target of interest temperature to the blackbody temperature and storing the difference in memory so as to use it a correction factor.” Needham describes a detector where the calibration is provided by intermittently having the detector measure a reference body (e.g., the inside of the case) and the objects to be measured. Again, there is no suggestion of having a subset of the detectors in an array gather calibration information while remaining detectors receive radiation from other portions of the scene.

Since Needham does not disclose any of the above noted features that are absent from the Walsall system, a combination would be similarly lacking. Therefore, Applicants respectfully submit that the independent claims are neither disclosed nor suggested by Walsall in combination with Needham.

The dependent claims depend directly or indirectly from claims 1, 27, or 29, all of which are believed allowable, and set forth additional limitations. For this reason alone the dependent claims are allowable.

4) Seifert et al (US 6652452)

The Examiner has rejected the independent claims (1, 27, and 29) and most of the dependent claims as obvious over Seifert in view of Eryurek and Pavlidis, stating that Seifert discloses all of the features of claim 1 except the particularly functioning microprocessor, which is shown by Eryurek, and the use of sources of known temperature and known emissivity, which is shown by Pavlidis.

Seifert discloses the use of an array of IR sensors to produce a 2D temperature map of a target. The array of sensors is fitted to the end of an endoscope and a heating element 23, 24 is provided within the endoscope apparatus, between the IR sensor array and the objective lens. To “calibrate” the array, the heating element is raised to a known temperature using current control and is sensed by the array.

Hence there are a number of clear distinctions between this and the present invention. Primarily, the reference element is provided inside the thermal imaging device between the center plane and the lens. As such, the reference source is not in the scene viewed by the thermal imaging device. Rather, since the reference source is not focused onto the array, when “on,” the detectors would be flooded with its radiation, obstructing any view of the scene, and it would not be possible to calibrate the instrument at the same instant as carrying out thermal imaging of the subject. Indeed, as pointed out at column 8, lines 9-10, “The heating element could only be energized during calibration procedures.”

Additionally, the calibration would be based on all the detectors receiving light from the reference heat source, with no detectors receiving light from additional portions of the scene.

Moreover, since the reference source is provided internally, any correction based on the heating element would not factor in any effect the lens or other environmental conditions may have on the radiation received by the array from the actual subject which is to be mapped. In other words, no truly accurate calibration can be achieved. Indeed, this problem is noted at column 8, lines 20 onwards and it is suggested that the window be cleaned using a flow of gas to minimise such effects.

Hence there is no disclosure of the reference source being provided in the same scene as the target object(s), and no possibility of real-time calibration. There is also no

disclosure of using a subset of detectors to determine a correction and applying this to other pixels.

Again, Eryurek is of little relevance to the present invention and provides no direction to one of ordinary skill in the art which would help such a person to arrive at the present invention.

Pavlidis is cited for the use of black bodies as the reference source(s). However, Pavlidis discloses nothing further than Seifert. There is no disclosure of any reference source being placed in the same scene as the target object, thus any calibration that is performed takes place prior to imaging the subject. This is evident from column 20 which discusses first performing a calibration sequence (lines 12 to 20) and then imaging the subject, during which the image is cropped to that it contains only the subject's face and no background (lines 44 to 50). Hence it is not possible to carry out any real-time calibration, and there is no use of a subset of pixels to determine a correction which is then applied to other pixels.

Therefore, Applicants respectfully submit that the independent claims are neither disclosed nor suggested by Seifert in combination with Eryurek and Pavlidis.

The dependent claims depend directly or indirectly from claims 1, 27, or 29, all of which are believed allowable, and set forth additional limitations. For this reason alone the dependent claims are allowable.

5) Barnes (GB 1014769)

The Examiner has rejected the independent claims (1, 27, and 29) and most of the dependent claims as obvious over Barnes in view of Eryurek. The Examiner has also rejected the independent claims (1, 27, and 29) and a few of the remaining dependent claims as obvious over Barnes and Eryurek further in view of Maccarone.

The Examiner asserts that Barnes discloses all of the features of the independent claims except the particular processor claimed, which is disclosed by Eryurek. However the Barnes system is fundamentally different from the present invention.

Barnes provides a thermal image using a single IR detector (item 18 in Figure 1) onto which radiation from the scene is scanned to build up an image. There is no array of

detectors. Hence the reference source is not, at any one instant, providing radiation to the IR detector while the target object is providing radiation to the IR detector. It is therefore not possible to conduct true “real-time” calibration. Moreover, it is not possible for any correction to be determined based on a subset of detectors, since only a single detector exists.

Moreover, Barnes does not produce any sort of calibrated temperature map, as achieved by the present invention, but merely provides a technique for producing a calibration bar by which a thermal image may be interpreted. Since no processor is provided, there is no processor for computing the thermograph. But more significantly, the thermal image itself is not adjusted according to the reference sources, but rather may be interpreted using the generated scale bar. There is no determination of any correction to be applied to the thermal image.

As already described, Eryurek discloses nothing which would assist one of ordinary skill in the art in addressing any of the shortcomings of Barnes.

In section 11, the Examiner cites Barnes and Eryurek further in combination with Maccarone (US6742925), suggesting in particular that Maccarone discloses the heat source being at least a portion of an object forming the scene being mapped.

Maccarone discloses a blackbody radiation source fixed to a mat which can be attached to any surface such as a wall in the scene of interest. The source is used to calibrate an IR thermometer by comparing readings of the reference source taken by the thermometer with measurements taken from a contact thermometer integrated into the mat.

As in the cases of Walsall and Sheffer, such IR thermometers can only take point measurements and this does not correspond to a thermal imaging device as required by the claims, and certainly not an FPA detector. Moreover, since the IR thermometer can only receive radiation from a single point at any instant, the reference source cannot be positioned within the same scene as the target object. Further, there is no possibility of using a subset of detectors to determine any correction, since only one detector is available.

Additionally, Maccarone does not disclose using a portion of an object forming the scene being mapped as the reference heat source, since here a black body is added to fulfill this role.

Maccarone therefore adds nothing to the disclosure of Barnes and Eryurek. Therefore, Applicants respectfully submit that the independent claims are neither disclosed nor suggested by Barnes in combination with Eryurek or with Eryurek and Maccarone.

The dependent claims depend directly or indirectly from claims 1, 27, or 29, all of which are believed allowable, and set forth additional limitations. For this reason alone the dependent claims are allowable.

Substantive Claim Amendments

Applicants have amended independent apparatus claim 1, first, to emphasize that the scene under observation cannot consist solely of the first heat source. Rather, as stated at lines 4 to 5, in addition to the first heat source, the scene contains “at least one target object.” Basis for this may be found at page 5, lines 7 to 9 as well as Figure 1 and the corresponding description at page 8, lines 21 to 32, where the target object is item 8.

Second, Applicants have amended claim 1 to specify the nature of the thermal imaging device, namely that it is “for detection of radiation emitted by the scene, the thermal imaging device comprising a focal plane array (FPA) detector having a plurality of detectors arranged in an array.” Basis for this may be found at page 9, lines 14 to 17, original claim 13 and page 12, lines 8 to 10.

Third, Applicants have amended claim 1 to specify the nature of the calibration carried out by the processor, such that the correction is “based on the known temperature of the first heat source and detected radiation data from a first subset of detectors that includes fewer than all of the detectors in the FPA, which first subset receives radiation from the first heat source while other detectors in the FPA receive radiation from other portions of the scene at the same time.” Further the correction is applied to “detected radiation data supplied by the thermal imaging device FPA to thereby generate the calibrated temperature map.” Basis for this may be found at page 9 line, 28 to page 10, line 6¹.

¹ The reference at page 9, lines 30-32 “that the group of pixels include only a subset of the pixels” is believed to provide support for the claim language to the effect that the first subset “includes fewer than all of the detectors in the FPA.”

Corresponding amendments have been made to independent method claims 27 and 29.

Applicants have also amended dependent claim 30 to recite an embodiment in which two heat sources are provided and specifies that the correction is further based on the known temperature of the second heat source and detected radiation data from a second subset of the detectors in the FPA, which second subset receives radiation from the second heat source. This is based on page 9, line 28 to page 10, line 6.

Applicants have also added a number of new dependent claims to emphasise certain features of the invention.

New claim 47 specifies that the target object and first heat source are located “alongside” each other in the scene, “such that any atmospheric absorption occurring between the first heat source and the thermal imaging device is substantially the same as any occurring between the at least one target object and the thermal imaging device.” Basis for this may be found at page 5, line 7 and page 6, lines 31 to 35.

New claim 48 requires that the scene corresponds to the field of view of the thermal imaging device. This is based on page 8, lines 24 to 26, and page 9, lines 14 to 15.

New claim 49 specifies that the correction is applied to data from each of the detectors in the FPA which receives radiation from the scene. Basis for this may be found at page 10, lines 6 to 7.

New claim 50 corresponds generally to amended claim 30 in that it relates to an embodiment in which two heat sources are provided and specifies that the correction is further based on the known temperature of the second heat source and detected radiation data from a second subset of the detectors in the FPA, which second subset receives radiation from the second heat source. This is based on page 9, line 28 to page 10, line 6.

New claims 51 and 52 make explicit that the temperatures of the first and second heat sources, respectively, are known independently of the thermal imaging device, which is entirely clear from the application.

New claim 53 corresponds to new claim 47. New claim 54 corresponds to new claim 48. New claim 55 corresponds to new claim 49. New claim 56 corresponds to new claim

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50 and the amended version of claim 30. New claims 57, 58, 59, and 60 correspond to new claims 51 and 52.

For the reasons discussed above, the amended claims are supported by the application as filed and distinguish over the prior art.

CONCLUSION

In view of the foregoing, Applicants believe all claims now pending in this Application are in condition for allowance. The issuance of a formal Notice of Allowance at an early date is respectfully requested.

If the Examiner believes a telephone conference would expedite prosecution of this application, please telephone the undersigned at 650-326-2400.

Respectfully submitted,

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